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ABSTRACT

This report provides information on the state of supply and demand for science teachers at the present time, and a projection of the situation in the mid 1980's. The demand for teachers since 1970, including science teachers, has fallen drastically, and very few teachers have been hired because of declining enrollment and fiscal problems. Teacher turnover has been sharply reduced creating an aging, static teacher population. Since 1973 the output of high school teachers in academic subjects has dropped 43 percent. This drop in teacher production coupled with a loss in teacher training capacity in colleges and universities will definitely lead to a shortage of science teachers in the mid 1980's, when an upturn of enrollment is expected to take place. (GA)

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SCIENCE EDUCATION INFORMATION REPORTS

Science Education Information Reports are issued to analyze and summarize information related to the teaching and learning of science education. It is hoped that these publications will provide information for personnel involved in development, ideas for teachers, and indications of trends in science education.

Your comments and suggestions for this series are invited.

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INTRODUCTION

In March 1976 the authors presented a paper calling attention to a possible shortage of science[1] teachers in the 1980s, due to a combination of economic problems in the schools, declining school-age population, decreased turnover of in-service teachers and a consequent aging of the teachers, heavy declines in pre-service teacher output, and reductions in the capacity of teacher training institutions to produce new teachers.[2] Much of the evidence came from statistics for teachers in general, for little is known about the teacher manpower situation for specific academic fields on a national basis, but enough information could be gathered on science teaching to indicate a strong possibility of problems ahead in demand and supply.

On the surface, that paper seemed to flout conventional wisdom. After all, there had been for th several years prior to 1976 a surplus of new graduates seeking teaching jobs. The Department of Health, Education and Welfare through the Office of Education, and later through the newly organized National Center for Education Statistics, had publicized projections of an enormous surplus of teacher supply over demand, including continued overproduction of new teachers, accumulating to monstrous proportions through the 1970s. For example, one report prepared for the Office of Education in 1972 that had broad implications for federal and local policy decisions stated:

> For the period 1971 to 1979...there will be 3,201,711 graduates (with teaching certificates)... This would represent over 2,000,000 graduates prepared to teach in excess of the need...[3]

The large surplus of newly trained teachers anticipated in this projection and others of somewhat lesser magnitude projected by the National Center for Education Statistics (NCES) as late as 1975 in their annual publication Projections of Education Statistics simply have not materialized. A study funded by NCES, the Preservice Preparation of Teachers, contains data based on a well-designed sampling of institutions that prepare teachers and students in those institutions. For the first time there are reasonable estimates available of the numbers of persons preparing to be teachers. The resulting report of this survey by Lewin and Associates has been submitted to NCES but has not yet been released by that agency. The statistics quoted from this survey were obtained

from a discussion draft of the contractor's report to NCES, which is also public information and is available through the ERIC system. The data show that, considering not only those who prepared to become teachers but also that subgroup who intended to seek jobs in teaching, for the year 1976-77 only about 25,000 would be unable to find teaching jobs out of approximately ten times that number who were in pre-service programs. This figure includes all teaching positions at all levels, and reflects both a drastically reduced demand and a large reduction in supply since the year 1969-70.(4)

However, the forecasts of 1972 and thereafter of exceedingly large surpluses of new teachers relative to demand had a profound effect. Decisions were made that were probably appropriate to the times when the existence of a surplus in teacher supply became obvious in 1972. The administration of the Education Professions Development Act (EPDA) began shifting emphasis from pre-service to inservice teachers, and to the training of teachers in certain specialties related to handicapped, bilingual, and disadvantaged children. The message was clear: curtail pre-service education programs. It was reflected not only in Federal government policy but in actions taken by state government education authorities. But the message was too simple; it ignored a whole set of counter-trends even then taking place. Moreover, it ignored the long-range effects of curtailment in the 1970s of pre-service teacher education in the colleges.

During the 1970s major changes occurred in the composition of the secondary school teaching staff, as well as in the constraints on the demand/supply system for teachers to which the country had become accustomed in the 1950s and 1960s. These changes will interact with the reduction in teacher training capacity imposed during the 1970s in an adverse fashion when we reach the 1980s. Little attention has been paid to those consequences.

The authors in their 1976 paper were concerned about the lack of usable statistics on placements of new teachers, turnover of the in-service staff, production of new teachers, actual size of classes (as opposed to estimated student/teacher ratio calculated from gross sources), and differences among academic disciplines or regions of the country was shown. We knew that there was a surplus of trained beginning teachers coming from colleges and universities, but was the surplus the same in all fields? Would the surplus continue unabated, even snowballing with ever-larger numbers of new teachers graduating

into unemployment? Was the retirement rate of experienced teachers constant through the 1960s, the 1970s, and projected into the 1980s? Could the present surplus generate its own feedback and turn off teacher production, even cause overreaction? Could the capacity to train new teachers become impaired by the late 1970s, making it necessary to rebuild this capacity if a need should develop for more teachers in the 1980s? What is the lead time for building up a teacher training capability, recruiting undergraduates into the program, assessing the then-current needs of new teachers for that era, and incorporating new requirements into the program? Is there a danger of a wave of retirements in the mid-1980s, particularly among science teachers? Would this turn into a sudden shortage of teachers because of severe reductions in science teacher production during the previous few years?

There seemed to be no mechanism for long-range planning or even fact gathering. Government agencies, notably the National Center for Education Statistics, did not have current and believable information on most of the indicators of teacher supply and demand that would provide a sense of developing trends, a situation that is discussed in considerable detail in this paper. Organizations of the various segments of the education professions seemed to be out of touch with the long-range possibilities of the changes that had been taking place. Two organizations that had been collecting statistics in past years for their own purposes--the American Association of Colleges for Teacher Education (AACTE) and the National Education Association (NEA)--were concerned with parts of the issue but were unable to provide current data on specific elements such as rates and trends of new teacher production (those who, upon graduation, will be seeking their first teaching jobs) and rates for teachers leaving the profession for all teachers in secondary school positions, let alone for those in science and math.

Most disappointing was the seeming indifference of education professionals as a group and their organizations to these questions. Since there was at the time an obvious teacher surplus, drastic policy decisions were being made all over the country to reduce production of new teachers. However, no group seemed to be considering the trends from the national viewpoint--certainly not in the science teaching professions. Each person seemed caught in his or her little niche, trying to cope with developing crises of staff or program on his/her own campus. The big picture was being lost.

THE PROBLEM

There may well be a severe shortage of high school teachers in the natural sciences and mathematics after 1985, perhaps even earlier. Very few teachers have been hired during the 1970s, and the existing teacher population is growing older. The output of new science teachers at the undergraduate level has tapered off, and even the machinery for producing new teachers is being partially dismantled. By the middle 1980s a large proportion of the teachers now in service will be reaching retirement age, but replacements will be in very short supply.

There is a strong possibility that the current surplus of new teachers may turn into a shortage by the middle 1980s. If this should happen, there will probably be a significant drop in the quality of science education taught in the high schools, which of course will quickly affect the colleges. Substandard teachers will then probably fill vacancies in science departments, and the curriculum needed to educate students for technically oriented careers would deteriorate.

The overall health of the science/technology components of our society may thus be threatened during the latter part of the century. The country's economy rests on the quality of its technology. For many years employment in the professions and in the industrial sector has increasingly demanded technical knowledge and skills. Forecasts indicate that this trend will continue. These skills are acquired only after a strong foundation in mathematics and the sciences has been provided during the normal years of schooling. The potential teacher shortage has serious implications for our economy and also for the employability of high school graduates and the competence of the working force.

The situation has its roots in the socio-economic problems of schools in the 1970s. After two decades of burgeoning growth and spiraling costs there has been a sudden freeze on expansion and a "hold the line" attitude on expenses. The school-age population started dropping at the kindergarten level in the late 1960s, and by now the decline has reached the secondary level.[5] Consequently the teaching force in high school academic subjects will remain relatively constant in size. Hiring of new, young teachers has

dropped greatly. In general, only replacements are being hired, and sometimes vacancies are left unfilled because of local problems. For a variety of reasons, a smaller loss to the system than in the 1960s has occurred from among the group of older, highly experienced teachers. Thus, there is an aging teaching population with very little infusion of younger people.

News of the hiring freeze affects the plans of college-age students who might otherwise enter the teaching profession.(6) Drastic drops in enrollments for preservice teachers have already taken place. As a consequence, colleges suffering from their own financial binds have been cutting back on their commitments to teaching programs.(7) By now, relatively few undergraduates are preparing to teach, and the supply of new teachers is drying up.

The demand for teachers since 1970--including science teachers--has fallen drastically. The National Center for Education Statistics (NCES) reports periodically on the size of the nation's staff of education professionals. From these reports it can be deduced that the average annual growth rate of classroom teachers (all fields, elementary plus secondary) from 1959 to 1969 was 4.16 percent; from 1969 to 1975, however, the average growth suddenly plummeted to 1.43 percent per year.(8) Furthermore, the NCES growth statistics are obscured by disproportionate increases in certain categories of teacher and "instructional personnel" not associated with the traditional academic areas: special education, occupational/vocational education, and some others. In fact, these categories are still considered in short supply nationally and hiring proceeds unabated. Therefore, if any net increase should appear in the total instructional force within the near future it will most likely be heavily weighted with these teachers.(9)

There is little reason to expect growth in the teacher force for the next decade, since both elementary and secondary school enrollments have been declining since 1973. In fact, decline in the total number of classroom teachers has probably already set in, and will continue until 1985. In the middle 1980s an upturn in elementary school enrollment is expected because of a change in the birth rate as the World War II "baby boom" generation begins producing families. This will cause a reversal of the decline for elementary teachers, but it will be several more years before this bulge reaches the secondary schools.(10)

The only other factor that could mitigate the magnitude of decline in the force would be decreases in pupil/teacher ratio. (The lower this ratio, of course, the greater the number of teachers that will be required to serve the same number of students.) There were dramatic decreases in this ratio in the 1960s and into the early 1970s, and NCES projects a continued decrease to 1984.[11] The best guess, however, is that this has already bottomed out, and may be reversed, despite NCES projections. Fiscal problems are becoming so severe that many school districts are known to be foregoing replacements of teachers who leave and are then increasing class size. While there are not yet any quantitative estimates of this trend, it appears in recent samplings of science enrollments carried out by Ohio State University as part of ERIC/SMEAC's periodic assessment of science teaching.[12]

Pupil/teacher ratio is one of those statistics that often seem to have little relation to the numbers of students a science teacher faces in each of his classes. There is reason to believe that class size may well be increasing for the high school teacher, because the ratio officially reported includes in the denominator instructional personnel without daily responsibility for a defined set of pupils. If these other-than-classroom teachers are gaining in number, as would appear to be the case, then the pupil/teacher ratio tells us less than we need to know about the actual load of the average classroom teacher--and changes in that load. At present there is legitimate pressure for equity in the education of handicapped children, and for provision of appropriate services for the emotionally disturbed student. Teachers with these special skills have been and will continue to be added to the staff, sometimes by legislative mandate, sometimes by court order. The science teacher functioning with the large majority of "normal" children, however, may find his class size increase a bit because of the sudden jump in costs of special education. At the same time, vacancies in the traditional academic fields may be unfilled, or at best filled for only a fraction of the vacant positions, for the same reasons of fiscal constraints. Statistics as they appear in national totals fail to sort out the components of the ratio, and leave the reader in doubt as to whether he is correctly interpreting the current literature on educational trends or must question the validity of the statistics reported.

NCES itself contributes to the confusion. Not only were their projections on the extent of preservice teacher overproduction through the end of

1970s grossly overestimated, but their projections on pupil/teacher ratios for the same period are open to question. NCES offers projections of continued declines in the ratio through the end of the decade merely by extrapolating the trend toward reduction encountered from 1963 to 1973[13] This flies in the face of all recent evidence of actions taken by school districts confronted with fiscal crises. The reasonable assumption is that pupil/teacher ratios in high school science classes will not decrease at all and in fact may rise. For purposes of this paper the authors assume no change in this variable from 1976 to 1985, a reasonably conservative guess based on current information.

If growth of the science teaching staff is ended, the only access that newly trained teachers have to placement in a school classroom is through teacher turnover. Mobility of experienced teachers has in the past contributed to employment opportunities for the new teacher with a recent B.S., or for one holding an M.S. without a tenured position. The present tight market has reduced that avenue almost certainly, but no data are available. Other teacher movements out of the profession--retirements, changing careers, assumption of administrative duties, deaths, leave for a few years to raise children--will continue.

For new teachers, these will be the openings they seek; how many vacancies there will be is conjectural. The rate of these movements out of the classroom is subject to fluctuation. The many personal and economic factors entering into teacher turnover coalesce into an annual rate, but this fluctuates within limits. For our purposes the useful component of the teacher turnover factor is teacher termination rather than the component due to lateral transfer from one position to another, since this is the source of vacancies in the system. NCES uses an estimated rate of 8 percent per year for teacher turnover--apparently synonymous with temporary and permanent termination--in projecting future demand for teachers, basing this figure on historical data.[14]

There is disagreement as to whether an 8-percent termination rate is applicable to the present teacher population. The Rand Corporation performed an intensive study of educational personnel for the Department of Health, Education and Welfare and published a series of reports under the general

title Analysis of the Educational Personnel System during 1973 and 1974. In the volume devoted to teacher turnover the following conclusions are reached:

> The standard predictive method in this field is simple trend analysis, but it is not valid here. There is substantial year-to-year variation in termination rates and no consistent trend, but even more important, estimates of future rates must be modified in light of the changes in the teaching profession. The most significant change is the tremendous expansion of the teaching force in the 1960s, followed by declining school enrollments in the 1970s. A concurrent change is the improved economic status of teachers. The political and organizational strength of teacher groups may allow working teachers to retain their economic gains even in the face of a teacher surplus.
>
> The results in this report indicate that termination rates will fall in the next few years because of the youth of the present teaching force and the attractiveness--and scarcity--of teaching jobs. But as the force ages, the rates should rise back to about 7-10 percent at the end of the decade.
>
> ...the teaching force now has a median age of only 35. As the flow of new people dries up the force will age, so the drop in retirements will be only temporary and retirements in the late 1970s and 1980s should be quite high. ...In sum, the overall rates of termination will fall because of the attractiveness of teaching jobs, the perceived difficulty of regaining a lost job, and the youth of the present force. In the 1960s the termination rates varied from about 7 to 10 percent. The effect of the factors listed here should be lowered rates to about 5 to 8 percent in the next few years, rising to 7 to 10 percent by 1980.(15)

The importance of a drop in the termination rate for teachers is in the reduction of openings for the new teacher. For example, in a teacher force of 2,200,000 a change of one percentage point (from 8 percent to 7 percent) would reduce teacher demand by 22,000; 2 percentage points would reduce it by 44,000. This represents perhaps a 12 to 25 percent possible reduction in

the net demand for teachers projected by NCES for 1977.[16] It would also have a chilling effect on the outlook for teacher education at the undergraduate level.

There are no recent data on teacher turnover statistics, although NCES has expressed a desire to conduct a study of this important factor. This is another area where current practices make it impossible to be informed about a rapidly developing social and economic trend in education, thus freezing policy to a series of guesses based on extrapolation of obsolete past trends or, even worse, intuitive judgment based on the biases of incumbent political appointees over whose signatures reports are issued to Congress.

Demand for new teachers has been estimated by NCES up to 1984. Given known statistics on student population, using estimated rates for pupil/teacher ratio and teacher terminations mentioned above, without any adjustments for the recent aberrations that must be taking place in these rates and that have disrupted smooth trends dating back into the 1960s, NCES projects a continued drop in demand for additional certificated teachers down to 145,000 in 1980. It will then pick up to 198,000 by 1984, although the expansion at that time will almost certainly be for the increased numbers of newly admitted elementary school children and should not affect high school teachers.[17]

It is our contention that the projection factors used by NCES for teacher terminations and pupil/teacher ratios actually lead to overestimates of teacher vacancies in the 1970s and mask the extent of the cycle in which the schools find themselves. The numbers of vacancies for new teachers will probably be fewer than NCES projects for the late 1970s and beginning 1980s because of the static character of the teaching population and the influence of economic forces in educational financing. This will have a peculiar effect, if it should turn out to be true. It will affect production of new teachers even more adversely and put even more pressure on teacher training institutions as their graduates find ever fewer opportunities to teach. The result would be smaller output of new teachers than anticipated and a smaller number of would-be teachers in the "reserve pool" of persons who might be tapped if vacancies open up. It may also lead to loss of teacher training capacity.

SUPPLY OF NEW TEACHERS

When vacancies in the teaching force occur, they are filled either by persons with (1) no previous experience but with all the prerequisites, (2) by those who lack certain qualifying requirements but are otherwise considered suitable (and who must meet all requirements within a specified time), or (3) by persons who have not been teaching in the last school year but who are qualified and available. This last is the "reserve pool" and little is known about its composition. A useful assumption is that the longer a person is in the pool without a teaching assignment the less likely he or she will accept one in the future; conversely, the most recent pre-service graduates in the pool are the best candidates for placement. The smaller the number of unplaced teachers recently trained, the smaller will be the number of the most likely and most desirable candidates. Thus, the supply of trained teachers during the 1970s (particularly now and for the next few years) is highly pertinent to issues of supply and demand in the 1980s.

For the moment, discussion will be concentrated on the production of new teachers. Statistics on the annual supply of new teachers are invariably estimates for several reasons. NCES receives annual reports from colleges on degrees granted, but these cannot be translated accurately into pre-service teachers. One cause for uncertainty is the difficulty of counting those who are preparing to teach but who are not matriculated for degrees awarded by colleges of education. This is especially perplexing at the secondary school level, for undergraduates may be enrolled as majors in liberal arts and sciences while at the same time taking courses required for teacher certification. Colleges and universities have varying methods of reporting graduates with these characteristics, often lumping them with other arts and sciences graduates, sometimes reporting them as graduates certified to teach, or even combining them with education degree graduates in one undifferentiated number. There are institutions where such a student may achieve a degree either from the college of education or arts and sciences, with no difference in the employment market. Others take little or no professional education courses as undergraduates, and then matriculate for master's degrees in education that identify their subjects of competency.

Thus, a head count of <u>education degrees</u> awarded overlooks a sizable percentage of secondary school teachers and a small number of elementary teachers.

It also includes persons prepared for a whole variety of positions in the school system who do not teach in the traditional academic fields of most interest to readers of this paper, or who even may not serve as classroom teachers at all. Statistics collected by the states and later reported by NCES can separate out the latter groups by category, but no precise estimates are available for the prospective teacher with a non-education degree. Science teachers fall into this category, with both education and liberal arts degrees.

Another difficulty with education statistics is the tendency to report both bachelor's and master's degrees in one lump. In many, if not most, states the master's degree is the standard for permanent certification of a teacher, making him "fully qualified." Administrators are interested in knowing percentages of "fully qualified," but reporting which includes in one number both bachelor's and master's degrees conferred is quite misleading. At first glance one may consider these totals as the newly produced supply of teachers ready for their first position. Master's awardees, however, consist of at least three groups: (1) those who are already employed by schools in teaching positions they will retain and who are earning advanced degrees while in service, thereby changing their type of certification and their placement on the salary scale; (2) those who are already teachers with some degree of tenure status, but who are seeking other education-related positions such as guidance counselor or administrator; and (3) those who have no present teaching position, or have never had one, and who obtain master's degrees before coming on the market for employment. The last group are new teachers. The first group are by far the most numerous.

For purposes of this paper, statistics that include master's degrees will be avoided. It is the supply of new teachers at the B.S. level, recently graduated from teacher training programs with either education or arts and sciences degrees, that is of interest here. These graduates are traditionally the prime source for filling vacancies, and inferentially also the largest source for an active reserve pool. Until the recently completed survey by Lewin and Associates, The Preservice Preparation of Teachers, there were no guidelines for estimating the percentage of liberal arts graduates who are qualified to teach at the B.A./B.S. level. There are no separate statistics for persons with teacher qualifications (including those with education degrees) in each of the disciplines taught in high school. The totals for

graduates with education degrees include the very large mass of those prepared for the elementary grades, plus other educational specialties, but omit the arts and sciences recipients equally qualified to teach. The usual approach therefore, is to fix a ratio of "eligible to teach" baccalaureates to the total of bachelor's level graduates, thereby setting a number for the size of the supply entering the job market in any one year.

The ratio of "eligible to teach" to total baccalaureates used by NCES for several years has been 30 percent of each graduating class. This factor was applied to total graduates and used for "official" estimates. Another factor was then applied because at one time 75 percent of the "eligibles" had been found to be actively seeking teaching jobs in their specialties. Thus, .30 x .75 x size of B.A. class = the number eligible to teach. Both factors were derived from historical data gathered by the National Education Association in their studies on supply and demand of teachers, and were thought to be valid for 1972.

Both these factors are highly suspect. NEA's figure for percent of class "eligible to teach" had been higher than 30 percent, and was corrected by the Rand Corporation team's study in 1973-74 to 30 percent because of systematic biases in NEA's methods. That research team then immediately rejected the 30 percent figure for the 1970s, presenting convincing evidence of a sharp and consistent downturn in production of new teachers from 1966 to 1972, and offered reasons why the true figure was even lower at the time of their report (1974) with even further declines for the remainder of the decade at least.[18] Furthermore, if in times of excellent employment prospects 75 percent of the "eligibles" actually sought teaching jobs, when the market became depressed there was every reason to estimate a lower percentage of "eligibles" seeking extremely hard-to-find teaching jobs. NCES, however, was slow in abandoning the historically established factors even when all current information showed that they were changing. This has led to absurdly high projections of a teacher surplus, misdirecting decision makers about its magnitude.

A flagrant example of inflexible perpetuation of obsolete estimates occurred in a release by the Office of Education which was at the same time a report to Congress and a publicity release mentioned repeatedly in the press. Using projections from NCES to arrive at the estimates of teacher surpluses this publication spread the word that "even the lowest projected

surplus in 1980-81 is about 70 percent greater than the 1975-76 surplus."[19] Figures were presented to show that depending on alternate estimates of teacher turnover for the demand component, the smallest surplus projected for 1980-81 of beginning teachers in relation to demand would be about 50 percent, while the largest surplus projected would be well over 150 percent![20]

This release translated into ordinary language stated that, after at least a decade of dealing with an over-supply of teacher trainees in high proportions, the education establishment would mindlessly continue to turn out large numbers of college graduates who could not find jobs in education for which they were trained. Perversely, it was projected, ever larger numbers of unemployables would be poured from the assembly line each year, because the number of college graduates would increase each year and .30 x .75 x the number of graduates would presumably enter the employment market for teaching jobs. The Rand Corporation reports were well in hand long before this publication surfaced, refuting the 30 percent factor, and yet no sense of balance is reflected at any time in the bulletin. It is no wonder that, with this "official" government report in hand, state legislators and educational administrators were willing to emasculate teacher education in the colleges.

Compounding the confusion is the 1976 edition of The Condition of Education, in which during the same year NCES began to use alternative rates to estimate percent of graduating class eligible to teach, apparently in response to Carroll and Ryder's critique.[21] One can only conjecture as to the reasons behind these conflicting approaches in the same department of the government, and the consequent dissonant messages broadcast to the profession, but it may be that the OE report was actually prepared much earlier and was released later than anticipated. Unofficial conversations imply that this could be the case. In any event, the lack of consistency is unfortunate, because it obscures the true extent of the problem for decision makers.

Let it be noted that students do read the papers and make career decisions in accordance with their understanding of future opportunities, although not all at the same time. Interest in preparing for a teaching career has declined. The American Council on Education conducts an annual survey of the incoming college freshman class. One item covers career intentions. Evidently feedback on teacher surpluses began to affect the freshmen by 1970. In 1968, 23.5 percent intended to teach; this went to 12.1 percent in 1972

and 7.7 percent in 1974. Freshman intentions to enter secondary school teaching are even more startling. In 1968, 14.4 percent of entering freshmen indicated a probable career in teaching at this level. (This was the graduating class of 1972.) Freshmen entering in 1970, when news of difficulty in finding jobs began to circulate, showed 11.3 percent seeking a secondary school teaching career. This percentage dropped to 6.5 percent by 1972, 4.2 percent in 1974, 3.7 percent in 1976, and in September 1977--the graduating class of 1981--only 2.9 percent of the entering freshmen were declaring careers in secondary school teaching. These data, of course, are for prospective teachers of all subjects and must be applied by inference to science teacher preparation.

Reference has already been made to Carroll and Ryder's empirical test of time lag in responses of undergraduates to news of teacher surpluses in making their own career choices (see p. 5). However, the report by Morra of Lewin and Associates to NCES points out significant deficiencies in the amount of direction given undergraduates about entering teaching careers. Only about a quarter of the students, according to their survey, received systematic counseling on careers in teaching prior to their own decisions to enroll in the program.[22] On the face of it this appears to be a serious oversight by teacher training institutions.

The Preservice Preparation of Teachers survey revealed a good deal of information on current trends in teacher supply that heretofore had been estimated by obsolete methods. Table 1 shows that about two-thirds of the 1975 baccalaureate graduates intended to seek employment immediately as a teacher, while almost 15 percent intended to enroll for graduate degrees in education. Variations among ethnic groups on these items are striking.[23]

Supply/demand estimates going back to 1961 are given in Table 2. They show the "seller's market" that existed in the early 1960s and the relationship between demand and undergraduate response as the source of supply for the next 15 years. We may note, for example, the constant annual growth in demand through 1969, followed by the beginnings of sharp declines in demand in 1970 as estimated by NCES. The supply element for the 1960s is probably reasonably accurate; they were provided by the National Education Association (NEA) and were found to apply to that era. By the late 1960s some systematic errors may have entered, but these data are the best available.

Table 1. Plans for work upon graduation and receipt of initial teaching certificate as expressed by recent teacher education graduates. Aggregate United States, AY 1975-1976.

	Employment As A Teacher	Other Employment	Graduate School In Education	Graduate School Outside Education	Undecided
All Groups Combined	66.7	5.1	14.5	5.9	5.2
Father Occupation Group					
Farm	81.3	1.4	7.9	6.9	1.8
Labor, Operative, Service	66.1	4.6	16.9	4.9	5.1
Crafts, Protective Service, Technical	67.0	6.8	12.5	5.1	5.7
Clerical, Sales	63.5	6.5	17.3	6.2	3.3
Managerial, Proprietor	67.8	4.3	16.1	4.8	4.0
Professional	64.4	5.1	12.7	8.3	7.4
Ethnic Background					
White	67.7	4.8	13.9	5.8	5.5
Black	56.6	6.0	25.3	5.8	2.0
Asian	44.1	3.7	24.9	11.7	11.0
Hispanic	84.7	-	15.2	-	-
American Indian	65.4	-	-	-	34.6

NOTE: Data are weighted national estimates based on a nationwide probability sample of 3600 persons in their final year of teacher preparation.

Table 2. Supply and demand for beginning teachers. Aggregate United States AY 1961 through 1976.

Year	Supply Of Beginning Teachers	Estimated Number of Persons Seeking Work[a]	Demand For Teachers
1961	140,000	103,300	140,000
1962	150,000	110,700	148,000
1963	151,000	111,400	168,000
1964	175,000	129,150	169,000
1965	196,000	144,600	167,000
1966	201,000	148,300	188,000
1967	245,000	180,800	184,000
1968	249,000	183,800	216,000
1969	275,000	203,000	216,000
1970	292,000	215,000	166,000
1971[b]	309,000	228,000	142,000
1972[c]	320,000	236,200	175,000
1973	322,000	237,600	168,000
1974	305,000	225,000	151,000
1975	259,000	191,000	176,000
1976[d]	227,000	167,500	144,000

a. Estimated by using the percent of graduates reporting that they would seek work as a teacher. See Table B-21.

b. Supply data for 1961-1971 provided by Dr. William Graybeal of the National Education Association.

c. Supply data for 1972-1975 are weighted national estimates based on a nationwide probability sample of 240 schools, colleges, and departments of education.

d. Supply data for 1976 are weighted national estimates based on a nationwide probability sample of 3600 persons in their final year of teacher preparation.

e. Demand figures for 1961-1976 were supplied by Dr. Mark Borinsky of the National Center for Education Statistics and include demand from both public and private schools.

However, the Preservice Preparation of Teachers survey applies to supply estimates from 1972 and thereafter. The lag in supply of new teachers compared to demand declines from 1970 through 1974 is most striking, with the peak in supply reached in 1973. Once the reaction set in, however, the supply of beginning teachers dropped by nearly one-third between 1973 and 1976! Market factors were at work, but undergraduates' commitment to their course of study seems to have created much hardship between 1971 and 1974 for many individuals.(24)

In Table 3 a refinement of the previous table reveals large differences according to teaching specialty. It shows the persistence (relatively speaking) of those in elementary education in the face of an abominable market for their services, but it also shows the drastic reaction among those interested in secondary school teaching. Between 1973 and 1976 the secondary school beginning teacher supply plummeted to a little more than half of the peak year. This table shows the need for separate statistics for secondary school teachers in all aspects of the manpower problem. This adaptation of the Preservice Preparation survey appears in an official NCES publication.(25)

It becomes apparent from these tables that the enormous surpluses of beginning teachers projected in the early 1970s failed to take into account the natural reactions of students in choosing undergraduate majors. Still to be examined, however, is the long-term effect on the institutions that prepare teachers of this sudden change in their output.

Another source of data for the same years confirms the depressed state of teacher education. The American Association of Colleges for Teacher Education (AACTE) collects information yearly from each of its member institutions on the total numbers of teacher education graduates by degree level. Although these data are collected for other purposes, they can be analyzed for gross trends on output of beginning teachers.

Table 3. Supply of beginning teachers, by selected area: 1972-73 to 1975-76 (Index: 1972-73 = 100)

Selected Area, Bachelor's Degree	1972-73 Number Graduates	1972-73 Index	1973-74 Number of Graduates	1973-74 Index	1974-75 Number of Graduates	1974-75 Index	1975-76 Number of Graduates	1975-76 Index
All bachelors	322,000	100	305,000	94.6	259,000	80.3	227,000	70.2
Special education (bachelor's)	21,000	100	23,000	109.9	24,000	111.0	25,000	117.4
Occupational/vocational (bachelor's)[a]	15,000	100	13,000	84.0	12,000	78.0	10,000	65.3
General elementary (bachelor's)	121,000	100	116,000	96.2	94,000	78.2	87,000	71.7
General secondary (bachelor's)	138,000	100	126,000	91.2	104,000	74.8	80,000	57.7

a. This figure represents bachelor's degree recipients with certification in occupational/vocational education only and does not include nondegree teachers available for teaching in occupational/vocational education.

NOTE.—Figures for 1972-73 through 1974-75 are weighted national estimates based on a probability sample of 240 teacher preparation programs. Figures for 1975-76 are weighted national estimates based on a probability sample of 3,600 persons in their final year of teacher preparation.

SOURCE: U.S. Department of Health, Education and Welfare, National Center for Education Statistics, "National Survey of the Preservice Preparation of Teachers," unpublished data.

The AACTE data combine in a single number both elementary and secondary graduates, plus those for special education and other specialties. No separation of subgroups is possible, so that the trends for secondary teachers are obscured in the totals. Nevertheless, several aspects of the decline in teacher training become evident from AACTE statistics for the years 1973-1976. (N.B. - these dates refer to the June or August graduates of those years.) For all member institutions the number in the "initial certification pool"—persons with their first teaching certificates—in 1973 was 283,628. In 1976 that number fell to about 190,000, a drop of exactly one-third.(26)

Since there are over 800 member institutions in AACTE (the number varies slightly from year to year), it was decided to examine trends for the largest producers of teachers, which are usually the largest and most influential producers of science teachers. A group of 42 institutions was identified as follows:

1. Graduated 1000 or more baccalaureates in teaching in at least one of the years 1973 - 1976; and

2. Had no data missing for those years that would be essential for this analysis.

These 42 member institutions are about 5 percent of all AACTE institutions, and almost 5 percent of all those that train teachers in the United States. However, about 23 percent of all baccalaureate degrees received from AACTE members in 1976 were obtained at these colleges and universities. The numbers of B.A./B.S. degrees for these years are shown in Table 4.

These numbers conform very closely with those reported by Morra in the Preservice Preparation Study, showing that the largest institutions are declining at least as rapidly as the entire body of institutions. More than half were from the states bordering the Great Lakes.

Table 4. Decline in teacher output for 42 of largest teacher producers, 1973-1976

Year	Number[a]	Index[b]
1973	60557	100
1974	53618	89
1975	45207	75
1976	40180	66

a. Source: Unpublished statistics supplied by the American Association of Colleges for Teacher Education, 1977.

b. Percentage of output for 1973.

A further analysis was made to identify sections of the country with the greatest and least declines in teacher production over this period. For this purpose 704 AACTE member institutions were found that had no data gaps in the four-year period. It should be noted again that these statistics include all persons receiving the first professional degrees qualifying them to teach, with approximately half in the elementary field. Elementary teacher degrees did not decline nearly as much as did secondary teacher degrees over this period, for Morra's data in the Preservice Preparation study showed that the number of elementary degrees in 1976 was 71.7 percent of those in 1973, while for secondary teachers the number in 1976 was 57.7 percent of those in 1973 (see Table 3). Thus, the following statistics contain an indeterminate mix of elementary and secondary teachers. Moreover, they are derived from a major fraction, but not all of the AACTE member institutions, and so the totals deviate somewhat from those found for all institutions. (The 1973-1976 decline for this set totals 28 percent, whereas that for all AACTE members was 34 percent.)

With these cautions in mind, it may be deduced from Table 5 that the "Sun Belt" shows the smallest declines, while the Plains and Great Lakes states have cut back far more drastically than realized from national statistics.

It was decided not to compute statistics for California because of a number of anomalies in the data for several large institutions; inconsistencies from year to year in these cases were so great that the original data were suspect. Since California, with its very large population, would constitute most of the weight for the Far West region, no figures are presented for the region as well. It should be mentioned, however, that all the other states in that region showed very large declines, with an index of 53 (Alaska) to 70 (Oregon).

Individual states show wide variation, but the Sun Belt—Midwest contrast is consistent. The extremes are given in Table 6.

The states Alaska, Hawaii, Nevada, and Wyoming all had indexes smaller than 60, but are not represented in Table 6 because each produces negligible amounts of new teachers, relying principally on one institution in each state.

Table 5. Regional declines in beginning teacher output, 1973-1976[a]

Region[c]	Index[b]
Great Lakes	63
Plains	65
Rocky Mountains	68
New England	72
Mideast	72
Southeast	82
Southwest	85
Far West	not determined

a. Source: Unpublished statistics supplied by the American Association of Colleges for Teacher Education.

b. 1973 output ÷ 1976 output x 100

c. Regional groupings:

Great Lakes: Illinois, Indiana, Michigan, Ohio, Wisconsin

Plains: Iowa, Kansas, Minnesota, Missouri, Nebraska, orth Dakota, South Dakota

Rocky Mts.: Colorado, Idaho, Montana, Utah, Wyoming

New England: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont

Mideast: Delaware, District of Columbia, Maryland, New Jersey, New York, Pennsylvania

Southeast: Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, West Virginia, Virginia

Southwest: Arizona, New Mexico, Oklahoma, Texas

Far West: Oregon, Washington, Alaska, California, Hawaii, Nevada

Table 6. States with greatest and least declines in beginning teacher production, 1973-1976

State	Index
South Dakota	53
North Dakota	55
Kansas	60
Ohio	61
Indiana	62
Illinois	63
Michigan	63
New York	63
Colorado	63
Utah	64
Iowa	66
West Virginia	66
Kentucky	67
Missouri	67
Nebraska	67
--	--
Florida	83
New Mexico	83
Georgia	84
Arizona	87
Texas	87
New Jersey	89
North Carolina	89
South Carolina	91
Alabama	94
Virginia	96

These two tables illustrate the remarkable shift now occurring in this country on centers of influence. In 1973 the five Great Lakes states, whose universities were among those with the largest teacher enrollments in the country, produced more teachers (53,552 for the institutions counted here) than any other region. The twelve Southeastern states were second with 46,772 new teachers. In 1976 the Southeast out-produced Great Lakes by 4500. Texas was among the large producers in 1973, ranking fourth. It is now first.

Science Teaching as a Special Case

The foregoing applies to teaching as a whole. Data on specific disciplines and the teachers of those disciplines are rarely found. In the absence of more precise information, the best assumption is that science teachers follow the general trends.

That fewer new secondary school science teachers are being hired now as compared to the early 1970s can be seen in the case of the State of New York. Most beginning science teachers in that state receive their baccalaureates from institutions that have authority to recommend provisional certification to the state. (Permanent certificates require specified amounts of graduate credits, to be gained within a stated period of time.) The number of provisional certificates issued to graduates of such institutions in four fields of science teaching reached a peak of 701 in 1973. Of these, 134 (19.1 percent) found teaching jobs in their specialties in New York State within the year following graduation. By 1975 only 570 graduates received provisional certification in these science teaching fields, and only 70 (12.3 percent found teaching jobs in their fields in New York State within the year. For mathematics the peak year was 1971, with 1022 provisional certificates and 424 persons (41.5 percent) finding math teaching jobs in the state within the year. By 1975 the number of provisional certificates had dropped to 715, with only 125 graduates (17.5 percent) finding math teaching jobs in the state within the year.[27] These statistics cover only jobs found within the state within one year, and do not reflect placements in other states or in later years for these graduates. They do indicate however, the condition of the teacher employment market in New York.

Table 7. New York State teacher certifications and placements, 1971-1975

Teaching Field	Number Provisional Certificates			Percent Placed First Year		
	1971	Peak Year	1975	1971	Peak Year	1975
Sciences	576	701 (1973)	570	17.0	19.1	12.3
Mathematics	1022	1022 (1971)	715	41.5	41.5	17.5
English	1972	2072 (1972)	1212	25.3	23.2	12.2
Social Studies	2198	2376 (1972)	1348	14.6	11.7	6.0
Vocational Programs*	1189	1226 (1973)	1052	43.1	40.6	26.7
Special Ed/Handicapped	450	1338 (1975)	1338	20.0	7.2	7.2
Elementary Ed	8682	9265 (1972)	8667	27.5	23.7	6.3
All Fields	19496	21824 (1973)	18197	27.7	21.9	9.8

*The sum of Home Economics, Industrial Arts, Business Education, Business and Distributive Education, Trade Subjects and Agriculture.

These figures indicate that science has been in a depressed condition in New York at least since 1971, and getting worse. When compared with other academic fields, science started at a lower level (with the exception of social studies, for which the situation has long been desperate), but now all seem to be in an absurd position with respect to rates of hiring the year after graduation. Vocational programs are in the strongest position in New York, both as to numbers enrolled in teacher preparation and percentage of placements. Elementary education may be described as in a state of disaster. The totals for all fields reflect the very high numbers of elementary teachers in training, although the total seems fairly representative of the entire picture. Placement of teachers of special education and the handicapped does not appear to have been accelerating in this state to the extent other studies have reported in the nation at large, and the growth in number of provisional certificates for these specialties issued between 1971 and 1975 raises some interesting questions.

These numbers document both the reduced hiring of new teachers in science and mathematics and also the decline in production of new teachers. For this northeastern state the statistics illustrate the word-of-mouth reports from other states in the populous eastern half of the country.

In 1975 the American Association for the Advancement of Science undertook an informal survey of pre-service teacher production, in conjunction with another study. Many of the largest teacher training institutions in the country, those traditionally producing large numbers of science teachers and in the aggregate educating the vast majority of the nation's new science teachers, were asked about recent trends. Responses were fragmentary, because in many cases the recipients of this questionnaire could not conveniently provide comprehensive data on the entire science teaching situation in their large institutions. Nevertheless, a large proportion of the major producers showed very significant declines since 1970.[28]

Experienced teachers are moving around less, keeping their teaching jobs whenever the alternatives to teaching are less attractive (e.g., during the economic climate of the 1970s), and retirements are thus confined to the oldest segment of the teacher population. At the other end of the spectrum, population declines and fiscal exigencies are ending the expansion of the science teaching force. New teachers are finding it exceedingly difficult to find

work because of the current surplus of beginning teacher applicants, and very few young teachers are being added to the staff. Obviously the stage is set for a progressively aging teaching population. As NCES states:

> With additions of young teachers greatly reduced, the composition of the teaching force can be expected to change. First, it will show an increasing chronological age and more years of experience. Furthermore, because most salary schedules reward seniority, the average salaries of teachers may rise even if there are minimal changes in current salary schedules.(29)

The Rand study puts it more bluntly: "In sum, it appears that if and when the surplus ends, the inertia in the system will lead to the almost immediate onset of a teacher shortage."(30)

This statement reveals a possibility not widely publicized, that the interplay between an aging teaching staff with a large proportion reaching retirement age in a short period of time, prolonged freezing out of young would-be teachers and their eventual discouragement to the point of refusal to enter into preparation programs, and a consequent drastically lower rate of teacher production leading to termination of many teacher programs, might well wind up in a critical shortage of classroom teachers who are properly qualified. It can be shown that high school science is in a particularly vulnerable position.

The Rand analyses do not deal with single disciplines taught at the high school level, but they do imply a differential effect on supply and demand according to disciplines. Science teachers are likely to be affected more seriously than are teachers in general by this combination of expected retirement (plus other losses associated with an aging population) and reduced supply of new teachers. As a group they are somewhat older than those in most other disciplines, for their numbers did not swell as much during the 1970s with new, young bachelor's degree holders as did the ranks of English and social studies teachers. This can be documented by close examination of statistics from several sources:

a. The series of reports issued by NEA on teacher supply and demand through 1973 revealed the relative expansion of the teaching force in secondary school academic fields between 1950 and 1972.

(Later NEA reports are less complete.) Science grew far less than most fields, both in production of pre-service teachers (an increase of only 21 percent for science compared with 180 percent for all secondary fields) and in numbers of teachers hired.(31) The same publication offers age distribution for all secondary teachers (see Table 8).

b. A sampling of science teacher characteristics and curriculum by Schlessinger, Howe, et al at Ohio State University in 1970-71. Age distribution of science teachers is significantly different from that of other secondary school teachers (see Table 8).

c. A report by NEA on their latest periodic survey of teacher characteristics and attitudes issued late in 1977 shows that during 1975-76 the median age of secondary teachers in general was 33, but that for science teachers it was over 36. The average number of years of teaching experience for all secondary teachers was found to be nine, and to be experiencing a downward trend.(32)

d. A preliminary report on a survey of science teachers during 1976-77 performed for the National Science Foundation showed the average years of teaching experience for science teachers to be 11.5. Unfortunately, age data were not collected.(33)

The age differential for science teachers is shown in Table 8. To project these figures to 1985 requires some assumptions about the factors that contribute to growth of the science teaching force, turnover of the existing teacher population, and consequently the age composition of the science teaching population in 1985. Then we may judge the extent to which present trends in the supply/demand process might, if extended to that time, remain appropriate or create problems.

Table 8. Ages of secondary schools teachers, 1970-71

	All Disciplines[a]		Science Teachers (Excluding Math)[b]	
Below 30	38.7%		29.3%	
30-39	25.9%		32.2%	
40-49	18.6%		22.9%	
50-59		16.8%	12.2%	15.6%
60 and over			3.4%	

a. Graybeal, op cit., p. 42.

b. From Schlessinger, F. R.; R. W. Howe, et al, A Survey of Science Teaching in Public Schools of the United States (1971) Volume 1—Secondary Schools, (Center for Science and Mathematics Education, Ohio State University, Columbus, Ohio, 1973), p. 87.

Concerning size of the secondary school science teacher force, there is no evidence of significantly increased science enrollments, a factor that could create demand if it should occur. On the contrary, a recent report by Ohio State University indicates some decline in course enrollments, at least in those traditionally considered to be science courses.[34] This should lead to a small contraction in the total numbers of teachers needed for science in the near future, both because of declines in the size of the high school student population and in the percentage of students enrolled in science courses.

With these trends staring school system decision-makers in their faces, there is no alternative to the following measures to reduce the number of teachers to those supportable under class size requirements: (a) in systems with a relatively young teacher force and a declining science enrollment, some teachers may be furloughed or discharged--those with least seniority, who will almost certainly be the youngest; (b) where teachers are considerably older, and no expansion has been possible for several years (the northeastern quadrant of the country and the Plains states will have many such districts) vacancies caused by teachers retiring or otherwise leaving the system will not be filled; (c) where school policies or union contracts provide absolute preference for retention based on seniority, science teachers may find themselves shifted to other subjects, or teachers from other subject areas may be detailed to teach science.

Each of the foregoing possible measures leads to either dismissal or no employment for the recent science teacher graduate, at least for the period beginning around 1976 and lasting to the end of the 1970s. There will undoubtedly be exceptions, school districts that will be recruiting new or experienced science teachers, but they will not be a significant factor for the next couple of years. The net result of declines in student population and enrollments seems to be the freezing out of younger teachers and retention of the more experienced, who include a core of decidedly older men and women.

The student/teacher ratio in science classes is almost certainly not going to decline, despite NCES projections that a trend toward reduction of this factor since the 1950s will continue indefinitely. The present fiscal picture of strained resources, inflation, and annually increasing teacher salaries leads inevitably to an expectation that the ratio will increase rather than decline.

Here again the newly certified teacher will be penalized, for the ratio may be increased by failing to replace teachers who leave or by releasing the non-tenured if there is a crisis situation. For reference purposes, from Schlessinger and Howe it can be deduced that the median high school science class in 1970-71 had about 24 students.[35] This may be compared with the NCES statistic of pupil/teacher ratio of 19.8 for public secondary schools in that year.[36] A survey of teachers during 1975-76 by the National Education Association showed that the average secondary school academic subject classroom had about 25 pupils, down from 26 in 1971.[37] The NCES projection for that school year was 18.6.[38]

If, however, no further growth is expected in the total numbers of science teachers between now and 1985, apparently there was some growth between 1970 and the present date. The best available estimates of this at the present time are the NCES statistics published in 1976, which show total numbers of classroom teachers separately for elementary and secondary schools, with projections up to 1984.[39] These figures indicate that any growth in the total secondary teaching force took place by 1976, and by now the numbers of teachers are dropping back to the 1975 level. From 1970 to 1975 there was a total growth of 10 percent for all fields. Assuming that all increases could be attributed to new B.S. graduates, that is, to those fortunate few young people who were placed at an average age of 22 immediately after graduation, and that all these remain in the system until 1985, they all will be in the age category 30-39 by then. Indeed, half or better will be at least 35 years old. It will also be assumed that this rate applies to science teachers as part of the secondary school teaching population. Therefore, the category of 30-39 will be larger by 10 percent of the size of the 1970 science teaching staff.

Some reduction in size of the teaching staff is to be anticipated between now and 1985 because of student enrollment declines. It is assumed that this will be accounted for by retirements of older teachers and reductions in force from among the teachers with least seniority, those who today are below 30.

The reduction will bring the teaching force to approximately 88.7 percent of its 1975 strength. This will be handled mostly by attrition, that is disappearance from the force of the teachers who were 50 and over in 1970, since by 1985 they will be more than 65 years old. Any excess of retirements over attrition will lead to replacement of young teachers. In practice there will

be a combination of attrition and reductions in force and all other teachers will age 15 years between 1970 and 1985. On balance for the entire teacher population the distribution for age groups should be as represented in Table 9.

In support of these assumptions, there are reports from ERIC/SMEAC that recently the average age of science teachers seems to have increased about one year per year.(40)

In this projection, not only is over 56 percent of the science teacher population over 45 years of age, but most of the rest are over 35. The consequences of a teaching force with almost one-fourth over age 55 should be considered very seriously. Losses to the system would be staggering within a few years. If the replacement pool is nearly empty, the dire predictions of quality loss in science teaching may come true. The issue then revolves around the capacity of teacher training institutions to respond to the demands for qualified new teachers when the call is sounded.

That prospect is not favorable. As the size of the teaching force diminishes teacher training will decline, first because of student loss of interest and then because lower head-counts and full-time equivalents (FTE's) inevitably lead to curtailment of the teaching program and faculty by the college administration. Even though education departments are seeking to compensate for loss of undergraduate enrollments by expanding their in-service teacher activities and through other entrepeneurial devices, the outlook is pessimistic for teacher training programs and faculty for the next five years or more.

If the demand for science teachers should increase in 1985 and thereafter, the atmosphere in teacher preparation institutions will have to permit expansion and recruitment of students well in advance of the year of demand. It takes four to five years of undergraduate preparation to graduate a qualified science teacher. The entering freshman class of 1981 is a likely target for "turn-around" recruiting. Groundwork for such a change in attitude takes at least two years for policy re-direction and institutional budgets to reflect the new priority. Are the teacher training institutions willing and able to start preparing for the future in 1978 and 1979?

Information Requirements

In this paper it has been necessary to assume a great deal and at times to make estimates beyond any verifiable, current data systematically collected. Continuing periodic monitoring during these unusual years is necessary for such important variables as: size of the teacher work force; age distribution of teachers; retirement rates and other teacher termination rates; student/teacher ratios for actual classes rather than for arbitrarily calculated indices of students to total professional force; numbers of vacancies filled each year, as well as vacancies unfilled; subject matter enrollments; and demographic characteristics of newly hired teachers. All of the foregoing are needed by subject area taught. Statistics such as these would keep the nation abreast of the demand for teachers.

On the supply side of the equation it is not difficult to monitor the annual production and placement, by subject taught, of new teachers. In addition, changes in institutional capacities to train teachers should be closely watched, since there is reason to believe that extensive attrition has started.

These two essential elements for policy planning, embodying teacher demand and supply are the responsibility of NCES. For the first time this year (the 1977-78 school year), NCES has surveyed local school districts for position vacancies at the beginning of the school year, and the numbers sought but for which no suitable candidates could be hired. NCES hopes to make this a biennial survey. Publication date should be some time in 1978. They also have established a biennial survey of teacher placement of recent graduates. Both of these surveys are by teaching field. The information should plug some of the gaps in our present knowledge.

Every effort should be made by the committees of higher education and the professional disciplines to encourage NCES in these monitoring functions. However, the science teaching profession itself has its own needs for data, and should be prepared to supplement the more general efforts of a national government agency by keeping close watch on its own subject areas.

The reserve pool of persons already qualified as teachers but not presently employed is a mystery today, and will be even more unfathomable with

each passing year. Presumably the reserve pool of science teachers will decrease in size over the years as numbers of new teachers prepared and unable to find work also decrease. After 10 or 15 years of surplus on the supply side, how many of those who were once ready to teach will still be willing and available? There have been predictions of a surplus of Ph.D. scientists, and some experts have implied that these will find themselves in the secondary school teacher reserve pool. Will they actually be available? In fact, is this surplus actually developing as forecast up to 1978? Recent data indicates an increase in employment rates for Ph.D.'s. In addition, are research-trained Ph.D.'s a suitable group for high school teaching?

The effects of a potential teacher shortage on the science and mathematics education of minority groups should be examined, as well as the long-term effects of the current fiscal emergencies faced by political jurisdictions with large numbers of minority group students and other disadvantaged. When teaching staffs are reduced, minority education is often the first to suffer. When shortages develop, there is a tendency to raid schools that are considered less desirable. The school with a preponderantly minority population may be the first to lose in the exaggerated cycle of glut and scarcity with which the nation is faced.

One element that should be stressed at this time is the appropriate posture for science teaching departments in teacher preparation institutions. Student enrollments are down, and it hardly seems to be the time for an aggressive look toward the future. Nevertheless, a year will come when increases in students seeking teaching careers are necessary, and when recruiting will be required. That day is closer than many realize. Preparing for 1985 takes lead time. The incoming freshman class of 1981 is the likely target and the institution must be prepared sufficiently in advance to accommodate an increased enrollment.

What should be the content of the teacher preparation program in science education for the 1980s? Are the appropriate models now in place? Is development currently going on so that the training envisioned for the 1980s will suit the schools and environment of that time? Science and teaching programs adapted to the 1960s are unlikely to be adequate for the next decade, and many of our teacher preparation colleges and universities have not been in a position to reconsider the program because of the series of crises of the last five years.

This is the year to re-examine science education preparation for the beginning teacher and the in-service teacher, looking ahead to the remainder of the century. With smaller enrollments some experimentation is justified in anticipation of an upturn ahead. Far from pessimism at the succession of discouraging events in the recent past, science teaching can treat the bottom of the cycle as a take-off point for renewed plans and a bright future.

POST SCRIPT

As this paper is being written, evidence is now appearing of another kind of development that may make trend analysis based on past years completely useless, and require continuous monitoring even more urgently. An article in the January 25, 1978 edition of the Washington Post speaks to the recent phenomenon of teacher disgust with important aspects of their jobs, and their willingness to take jobs in other fields, even to the extent of refusing opportunities to return to teaching after being furloughed or to accept appointments for which they are eligible. The New York City Board of Education found that of 17,500 teachers who had been laid off, about 12,000 were no longer interested in a teaching career. Conditions of employment and atmosphere in the schools seem to be causing disaffection among both experienced and relatively new teachers.(41)

This article mentions the plight of New York City. The shortage of science and mathematics teachers has already hit that city. New York's experience may be the forerunner of a new crisis in the schools based on the unavailability of sufficient numbers of qualified teachers in both the in-service ranks and the supply of beginning teachers. It may even affect the reserve pool. The problem stems from the growing social and economic problems of school districts, especially in the large cities but not excepting the suburbs and even rural areas.

A recent survey by the National Education Association (NEA) documents some of these attitudes. Every five years NEA has been "taking the pulse" of teachers covering their attitudes as well as some vital statistics of demographic nature. The 1975-76 survey, just published, shows much dissaffection among classroom teachers, and a greater than expected loss of highly experienced teachers in the last couple of years. However, the number of teachers in their first or second year of teaching has dropped to an all-time low.(42)

Troubles may be piling up.

SUMMARY

Although a surplus of high school science teachers may still describe the supply/demand situation for 1978 and 1979, much evidence points to an impending shortage of science teachers in the 1980s. Unprecedented developments in the economic and social factors affecting the schools in the last ten years have upset the traditional system of teacher supply and demand. Very few newly certified teachers have been hired for high school academic subjects in the last five years because of school population declines and local fiscal problems. Teacher turnover has been sharply reduced. The result has been an aging, static teacher population. Separate statistics for science teachers apart from teachers in general are often not available, but combinations of information from several sources seem to confirm that the adverse trends for teachers in general are at least equalled in science. For example, the average age of high school science teachers is greater than that of secondary teachers in general, and they tend to be more experienced.

As they reach retirement age a large number of the present teaching force will be ready to leave, but their replacements may not appear because of still another concomitant of the same social and economic trends--a drastic reduction in production of beginning high school science teachers in this decade. Since 1973 the output of high school teachers in academic subjects has dropped by 43 percent, and the downward trend is apparently continuing. Declines have been greatest in those states with institutions that traditionally have produced the largest numbers of teachers--the Great Lakes states. A similar decline is seen in the Plains states. The Southwest and Southeast, on the other hand, have shown only moderate declines. The drops in teacher production have been accompanied by loss of teacher training capacity in colleges and universities, since those institutions are also confronted with fiscal problems, and lack of placement for teaching graduates seems a good reason to cut back on pre-service programs. A likely result is that teacher preparation institutions will not be able to supply new teachers when the demand for them suddenly reappears. A cycle of shortage, glut, and again shortage seems to be characteristic of teacher manpower in this country.

Statistics from a variety of sources are examined in this paper. It is shown that the projections of teacher supply and probably teacher demand issued

by the National Center for Education Statistics (NCES) have been very misleading, and at times helped to fuel the problem. Quite recently NCES funded a study of teacher supply that documents the drastic declines already gathered from other sources. NCES has also begun to collect data on teacher vacancies filled and unfilled in local school districts, but results are not yet available.

More detailed information is needed on how these interacting factors are affecting science teaching in the schools. Quality considerations for both the present and the near future are of paramount importance. Supply of competent teachers for the classroom and their placement are key elements in such an examination.

Very recent evidence has come to light that a shortage of science teachers may already be appearing in special situations.

REFERENCES AND NOTES

1. Throughout this paper unless otherwise indicated "science" includes mathematics as well as the natural sciences. Social science is not included.

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4. Morra, F. The Supply and Demand for Beginning Teachers Past, Present, and Future. Washington, D.C.: Lewin and Associates. Table B-1 of Appendix B, April 1977. (Discussion Draft.)

5. Golladay, M. A. The Condition of Education (1976 Edition). Washington, D.C.: Center for Education Statistics, March 1976, p. 182.

6. See Carroll, S. J. and K. F. Ryder, Jr. Analysis of the Educational Personnel System: V. The Supply of Elementary and Secondary Teachers (R-134-HEW, February, 1974). Chapter 5, for an empirical test of the time lag and the degree to which news of teacher surpluses affects undergraduate choices.

7. For example, Utah has imposed quotas for teacher preparation programs in all state-supported schools.

8. Golladay, M. A., op. cit., p. 246. Statistics of Public Elementary and Secondary Day Schools, Fall 1975. Washington, D.C.: National Center for Education Statistics, 1976, p. 18.

9. Kusskraa, V. A.; F. Morra; and J. P. Brashear. The Condition of Teacher Education, 1977. Washington, D.C.: Lewin and Associates, Inc. Prepublication draft of report to NCES.

10. Simon, K. A. and M. M. Frankel. Projections of Education Statistics to 1984-85. National Center for Education Statistics, 1976, p. 61.

11. Ibid., p. 62.

12. Dr. Robert W. Howe, Director of the ERIC/SMEAC at Ohio State University, disclosed this information in a preliminary oral report of a 1975-76 follow-up to a 1971 survey of science teaching in the United States, at the annual meeting of NSTA on March 28, 1977.

13. Simon, K. A. and M. M. Frankel., op. cit., p. 62.
Golladay, M. A., op.cit., pp. 125, 247.

14. Simon, K. A. and M. M. Frankel, op. cit., p. 63.

15. Keeler, E. B. Analysis of the Educational Personnel System: IV. Teacher Turnover (R-1325-HEW). The Rand Corporation, October 1973, pp. v, 22-23.

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16. Simon, K. A. and M. M. Frankel, op. cit., p. 63.

17. Ibid.

18. Carroll, S. J. and K. F. Ryder, op. cit., p. 34 et seq.

19. Projections of Teacher Supply and Demand to 1980-81. Commissioner's Report on the Education Professions for 1974-75. Washington, D.C.: U.S. Office of Education, 1976, p. 4.

20. In estimating demand for teachers, the other end of the equation, OE used the very questionable assumption of a continuing decline in student teacher ratio. They did, however, accommodate to probable changes in teacher termination rate by giving alternative estimates of demand from 8 percent of the teacher force leaving the field each year, to 6 percent as recommended by an expert (Froomkin) down to 4.8 percent computed by the Bureau of Labor Statistics from actual census-obtained age distributions of teachers. The authors of the present paper believe the 4.8 percent figure applies to the 1970s, but the percentage should almost double by the middle 1980s.

21. Golladay, M. A., op. cit., p. 248.

22. Morra, F., op. cit., p. 74.

23. Morra, F., op. cit., Table B-21 in Appendix B.

24. Ibid., Table B-I in Appendix B.

25. Golladay, M. A. The Condition of Education (1977 Edition). Washington, D.C.: National Center for Education Statistics, 1977, p. 167.

26. AACTE Bulletin, Vol. 29, No. 10 (February, 1977), p. 3.

27. Employment Rate in Field of Certification of Persons Receiving Teaching Certificates, by Certification Category, New York State, 1971-75. Albany, New York:, New York State Education Department, 1977, unpublished document.

28. Hausman, H. J. Acceptance of the AAAS/NASDTEC Guidelines and Standards for the Education of Secondary School Teachers of Science and Mathematics (1971). Preliminary study presented to Arthur H. Livermore, AAAS (1975), p. 32.

29. Golladay, M. A., op. cit., p. 124.

30. Carroll, S. J. and K. F. Ryder, op. cit., p. 104.

31. Graybeal, W. S. Teacher Supply and Demand in Public Schools, 1973. National Education Association, 1974, pp. 9, 16, 28.

32. Status of the American Public School Teacher, 1975-76. National Education Association, 1977, Appendix C.

33. Weiss, I., in a paper delivered at annual meeting of AAAS during the symposium: Issues in Science Education, February 15, 1978.

34. Howe, R., in a paper delivered at annual meeting of AAAS during the symposium: Issues in Science Education, February 14, 1978.

35. Schlessinger, F. R.; R. W. Howe, et al., op. cit., p. 107.

36. Simon and Frankel, op. cit., p. 62.

37. Status of the American Public School Teacher, 1975-76. National Education Association, 1977.

38. Simon and Frankel, op. cit., p. 62.

39. Ibid., p. 61.

40. Verbal report by Robert W. Howe, op. cit.

41. Lescaze, Lee. N.Y.C. Hurting For Teachers. Washington, D.C.: Washington Post (January 25, 1978).

42. Status of the American Public School Teacher, 1975-76. Washington, D.C.: National Education Association, 1977.